UM11066

TEA1936xDB1521 USB_PD 45 W mobile charging demo board

Rev. 1 — 31 May 2018 User manual

Document information

Information	Content
Keywords	TEA1936xDB1521, TEA1936x, universal serial bus, power delivery, USB-PD, type-C
Abstract	This user manual describes the performance, technical data, and the connections of the TEA1936xDB1521 demo board. The TEA1936xDB1521 demo board operates at mains voltages from 90 V (AC) up to 264 V (AC) with an output voltage from 5 V (DC) up to 20 V (DC).

Revision history

Rev	Date	Description
v.1	20180531	first issue

1 Introduction

Warning	
 	The non-insulated high voltages that are present when operating this product, constitute a risk of electric shock, personal injury, death and/or ignition of fire. This product is intended for evaluation purposes only. It shall be operated in a designated test area by personnel qualified according to local requirements and labor laws to work with non-insulated mains voltages and high-voltage circuits. This product shall never be operated unattended.

This user manual describes the operation of the TEA1936xDB1521 demo board. The TEA1936xDB1521 features the quasi-resonant controller TEA19361, the synchronous rectifier controller TEA1993, and the USB-PD Type-C controller TEA19031.

The TEA1936xDB1521 demo board is designed for delivering a maximum output power of 45 W at a maximum current of 3 A. Output voltages can be chosen from 5 V up to 20 V.

The TEA1936xDB1521 provides an effective solution with a low current ripple and high efficiency for USB-PD and quick charge applications.

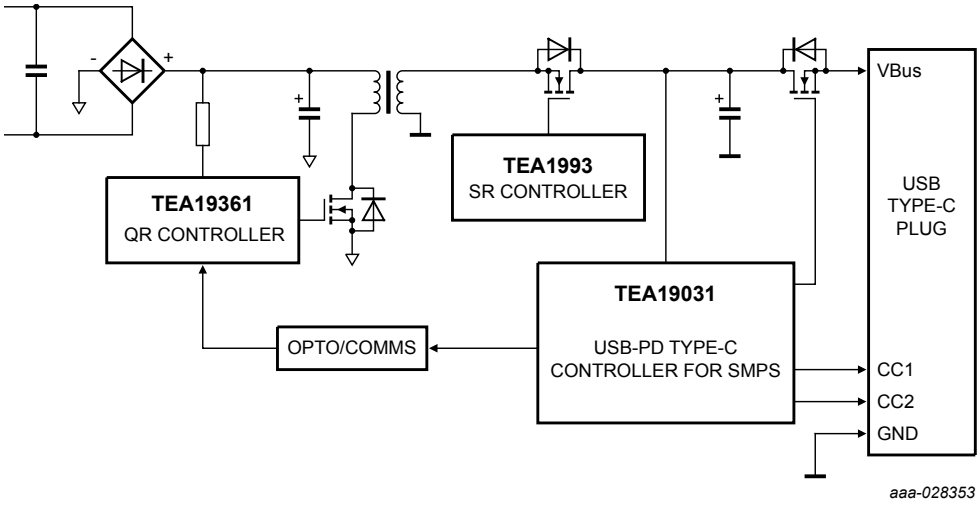

Figure 1. TEA1936xDB1521 principle schematic

1.1 Key features

- Multi-protocol support for USB-PD 2.0 and 3.0
- Functionality user-configurable end of line
- Best-in-class energy efficiency meeting all DOE & EU CoC requirements
- < 30 mW no-load power, low audible noise, low output voltage ripple
- Small size due to high near-full digital integration level and > 15.9 W/CI power density
- Best-in-class Thermal management
- Safe solution with extensive set of hardware-integrated protection features
- Complete one-stop-shop solution from NXP Semiconductors minimizing development time and research and development cost

1.2 Applications

Mobile chargers with Type-C connector for:

- Mobile phones
- Smart phones
- Tablets
- Notebooks

The new smart charger platform of NXP Semiconductors helps designers of travel adapters to maximize power output for the smallest form-factor with a short bill of materials.

The result is a cost-effective design. It meets the requirements published by Energy Star, the Department of Energy (DoE) in the United States, the Ecodesign Directive of the European Union, the European Code of Conduct, and other guidelines.

Supporting hardware (UTC) and software (GUI) for USB-PD available for jump-starting application.

2 Safety warning

The TEA1936xDB1521 demo board is connected to the mains voltage. Avoid touching the board while it is connected to the mains voltage and when it is in operation. An isolated housing is obligatory when used in uncontrolled, non-laboratory environments. Galvanic isolation from the mains phase using a fixed or variable transformer is always recommended.

Figure 2 shows the symbols on how to recognize these devices.

a. Isolated

b. Not isolated

Figure 2. Isolation symbols

3 Specifications

Table 1. TEA1936xDB1486 specifications

Symbol	Parameter	Value
V_{mains}	AC mains voltage	90 V (AC) up to 264 V (AC)
$P_{out(max)}$	maximum output power	45 W
f_{mains}	mains frequency	47 Hz to 63 Hz
P_{idle}	no-load input power	< 30 mW
η	efficiency	> 92 %; at $P_{out(max)}$
V_{out}	output voltage	5 V (DC) to 20 V (DC)
$I_{out(max)}$	maximum output current	3 A
$V_{ripple(burst)}$	output voltage ripple in burst mode	100 mV (p-p); at cable end
$V_{ripple(full)}$	output voltage ripple at continuous switching	80 mV (p-p); at cable end
EMI	conducted EMI	−7 dB
CMN	common-mode noise	< 2 V (p-p)
ESD	electrostatic discharge	±15 kV; through air
		±8 kV; via contact

4 Board photographs

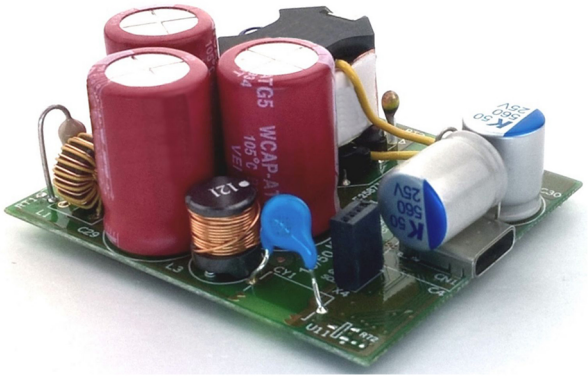

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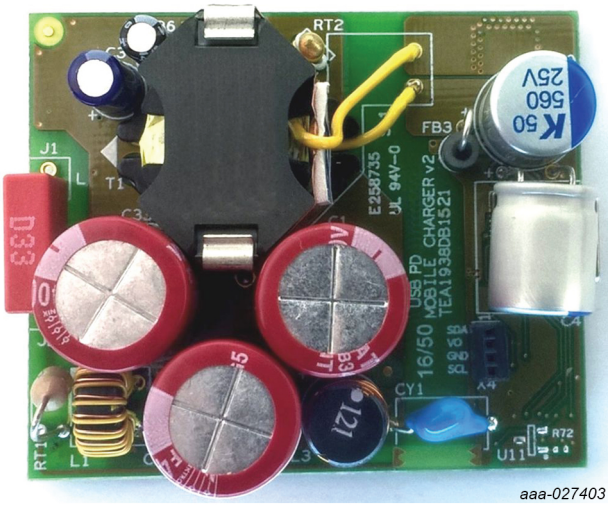
Figure 3. TEA1936xDB1521 demo board



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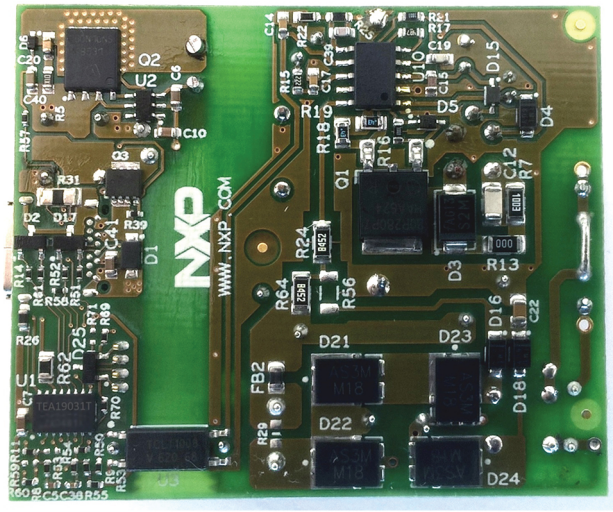
a. Top view



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b. Bottom view

Figure 4. TEA1936xDB1521 demo board

5 TEA1936xDB1521 demo board connections

The TEA1936xDB1521 demo board is a universal mains supplied application. The output is the Type-C receptacle. Setting the output voltage is done through the USB type-C interface. Additionally, the TEO II graphical user interface software provides the option to program other output voltages and limit currents into the TEA19031 PD controller IC. Section 7 lists the default settings.

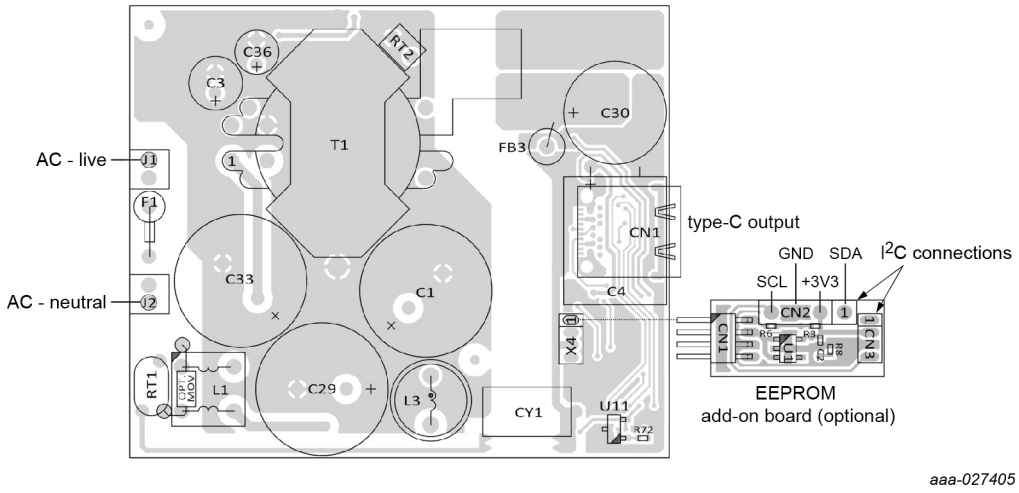


Figure 5. TEA1936xDB1521 demo board connections

6 TEA1936xDB1521 demo board performance

6.1 Efficiency

Table 2. Efficiency at 5 V output (PCB end)

Load	Efficiency at 115 V (AC)(%)	Efficiency at 230 V (AC)(%)
10 % (0.3 A)	87.8	84.4
25 % (0.75 A)	88.6	85.7
50 % (1.5 A)	89.3	86.6
75 % (2.25 A)	90	86.9
100 % (3 A)	90.1	88.9
4-point average	89.5	87

Table 3. Efficiency at 9 V output (PCB end)

Load	Efficiency at 115 V (AC)(%)	Efficiency at 230 V (AC)(%)
10 % (0.3 A)	88.5	86.1
25 % (0.75 A)	90.0	87.6
50 % (1.5 A)	91.2	89.0
75 % (2.25 A)	92.5	90.7
100 % (3 A)	92.4	92.1
4-point average	91.5	89.8

Table 4. Efficiency at 15 V output (PCB end)

Load	Efficiency at 115 V (AC)(%)	Efficiency at 230 V (AC)(%)
10 % (0.3 A)	86.5	84.8
25 % (0.75 A)	88.8	87.7
50 % (1.5 A)	91.8	90.5
75 % (2.25 A)	93.2	92.0
100 % (3 A)	92.9	93.0
4-point average	91.7	90.8

Table 5. Efficiency at 20 V output (PCB end)

Load	Efficiency at 115 V (AC)(%)	Efficiency at 230 V (AC)(%)
10 % (0.23 A)	86.1	84.2
25 % (0.575 A)	88.9	87.5
50 % (1.15 A)	91.8	89.9
75 % (1.725 A)	92.8	92.3
100 % (2.3 A)	93.0	92.8
4-point average	91.6	90.6

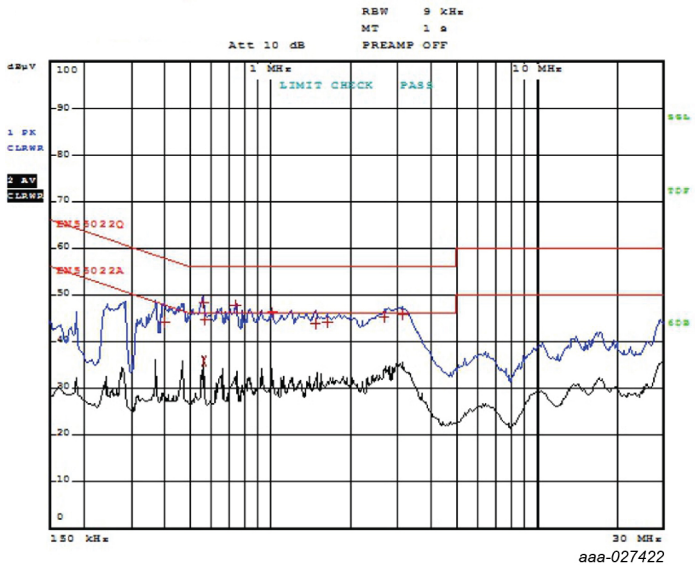
6.2 No-load power consumption at 5 V output

Table 6. No-load power consumption

Type-C cable disconnected.

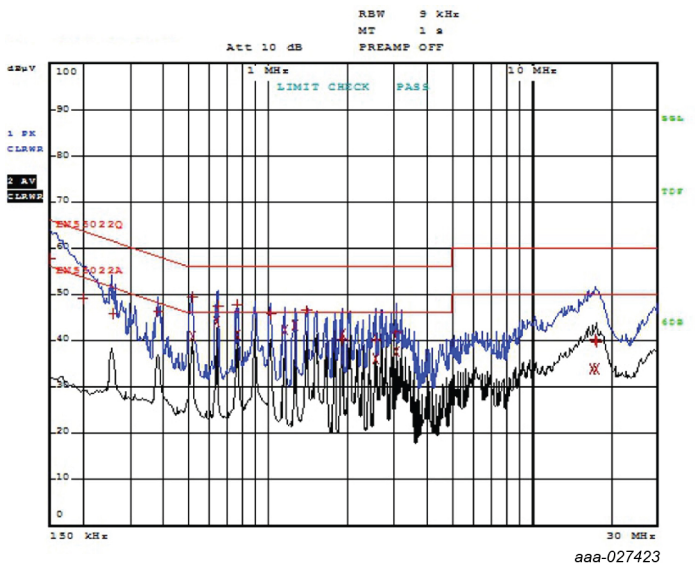
Input voltage (V (AC))	Input frequency (Hz)	No-load power (mW)
90	60	21.1
115	60	21.6
150	60	22.2
180	50	22.3
200	50	22.9
230	50	23.9
264	50	28.4

6.3 ElectroMagnetic Interference (EMI)



Protective earth is connected to secondary ground.

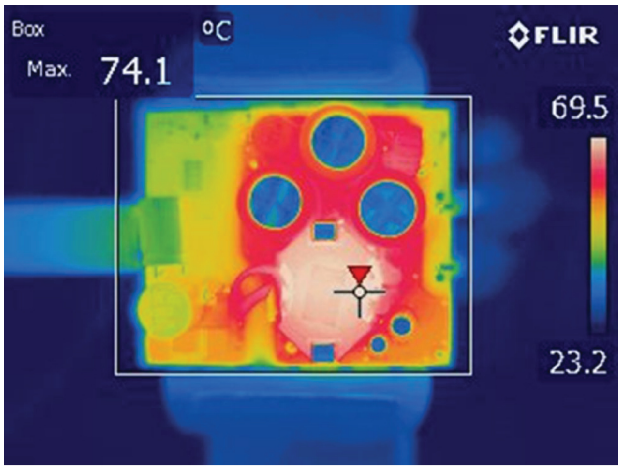
Figure 6. Conducted EMI at full load 115 V (AC)/60 Hz



Protective earth is connected to secondary ground.

Figure 7. Conducted EMI at full load 230 V (AC)/50 Hz; pass with > 5 dB margin

6.4 Thermal



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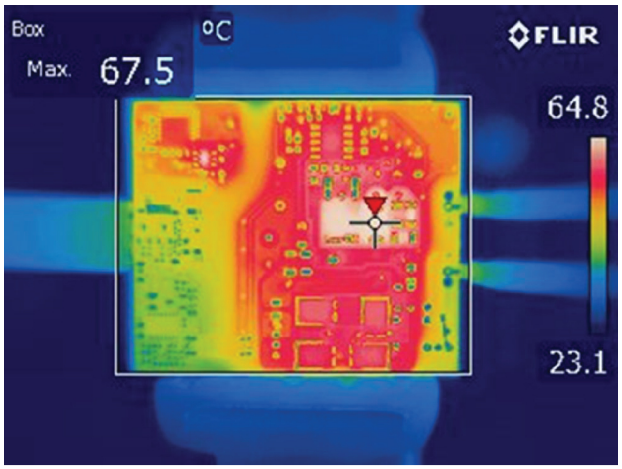
a. Top side



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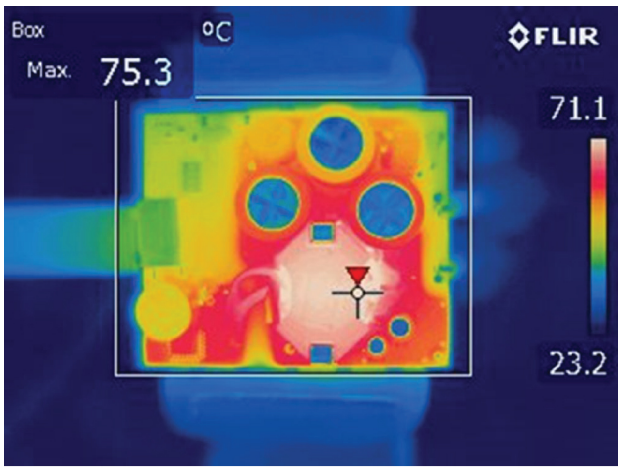
b. Bottom side

Figure 8. Thermal performance; V_{in} = 115 V (AC); P_{out} = 45 W



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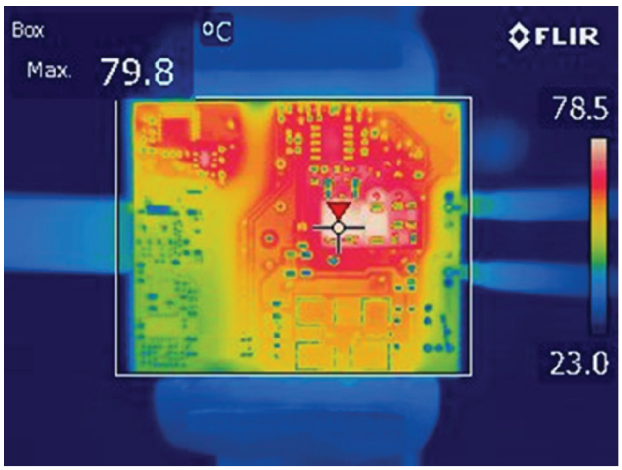
a. Top side



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b. Bottom side

Figure 9. Thermal performance; V_{in} = 230 V (AC); P_{out} = 45 W

Note: *Typical temperature distribution at T_{amb} = 25 °C; PCB in free air, natural convection, and radiation only. For the TEA1936xDB1521 demo board, the voltage levels must not exceed 20 V also. Current limit levels must not exceed 3 A. Power limit levels must not exceed 45 W.*

7 PDO settings

Table 7 shows the settings of the output voltages and currents for the efficiency measurement.

Table 7. PDO settings

Default values for demo board TEA1936xDB1521

PDO (#)	V_{out} (V)	I_{out} (A)
1	5	3
2	9	3
3	15	3
4	20	2.3

PDO settings can be changed by reprogramming the MTP settings of the TEA19031 via UTC using the TEO-II software (see the TEA190x Evaluation Overdrive (TEO) user manual (Ref. 1).

Note: *The PDOs must have an ascending voltage and power in order to work correctly. So, V(PDO, i + 1) > V(PDO, i) and also P(PDO, i + 1) > P(PDO, i). Also, for the TEA1936xDB1521 demo board, the voltage levels must not exceed 20 V. Current limit levels must not exceed 3 A. Power limit levels must not exceed 45 W.*

8 Schematic

The schematic of the TEA1936xDB1521 comprises the TEA19361 quasi-resonant controller, the TEA1993 synchronous rectifier controller, and the TEA19031 USB-PD controller.

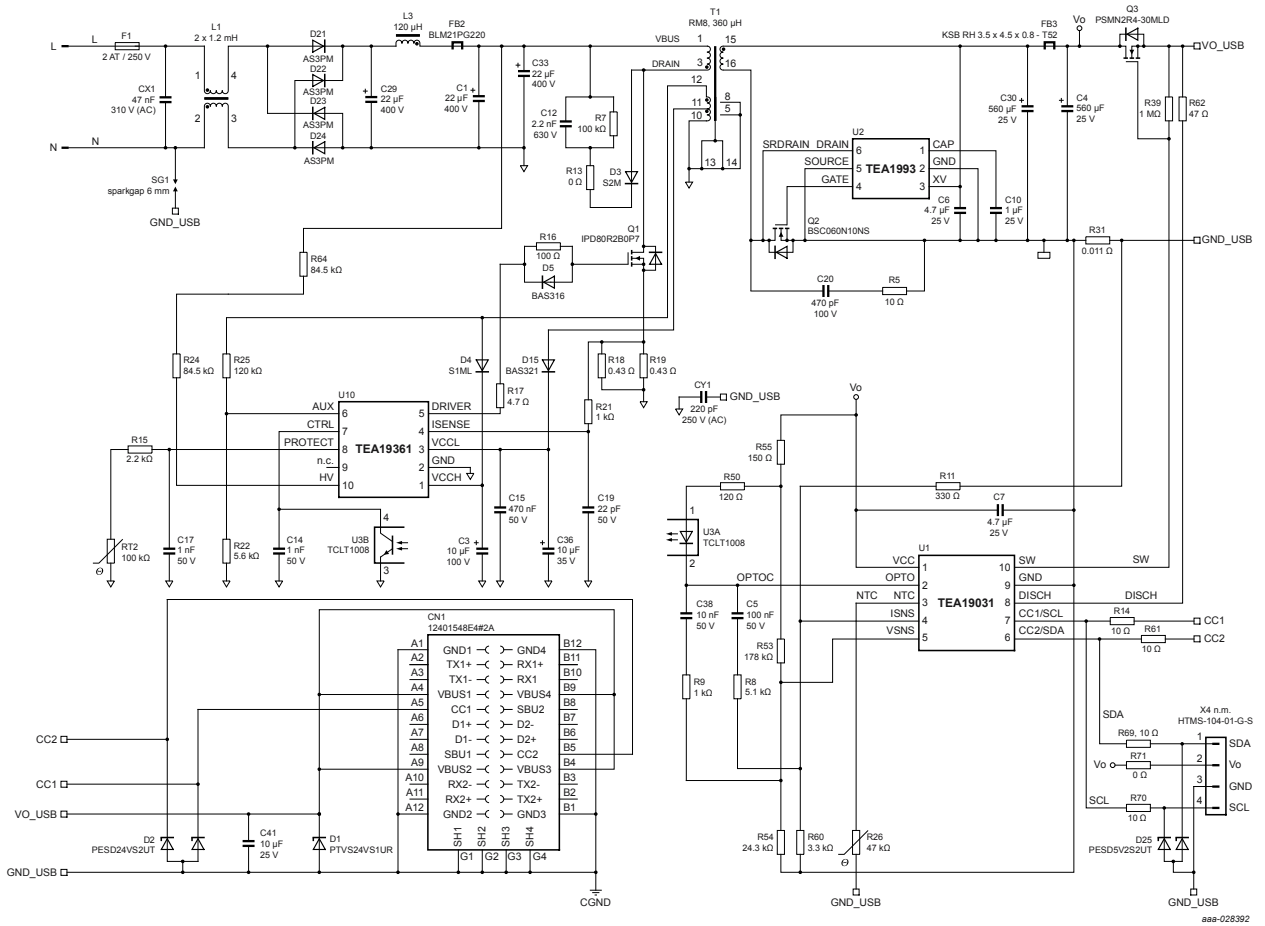
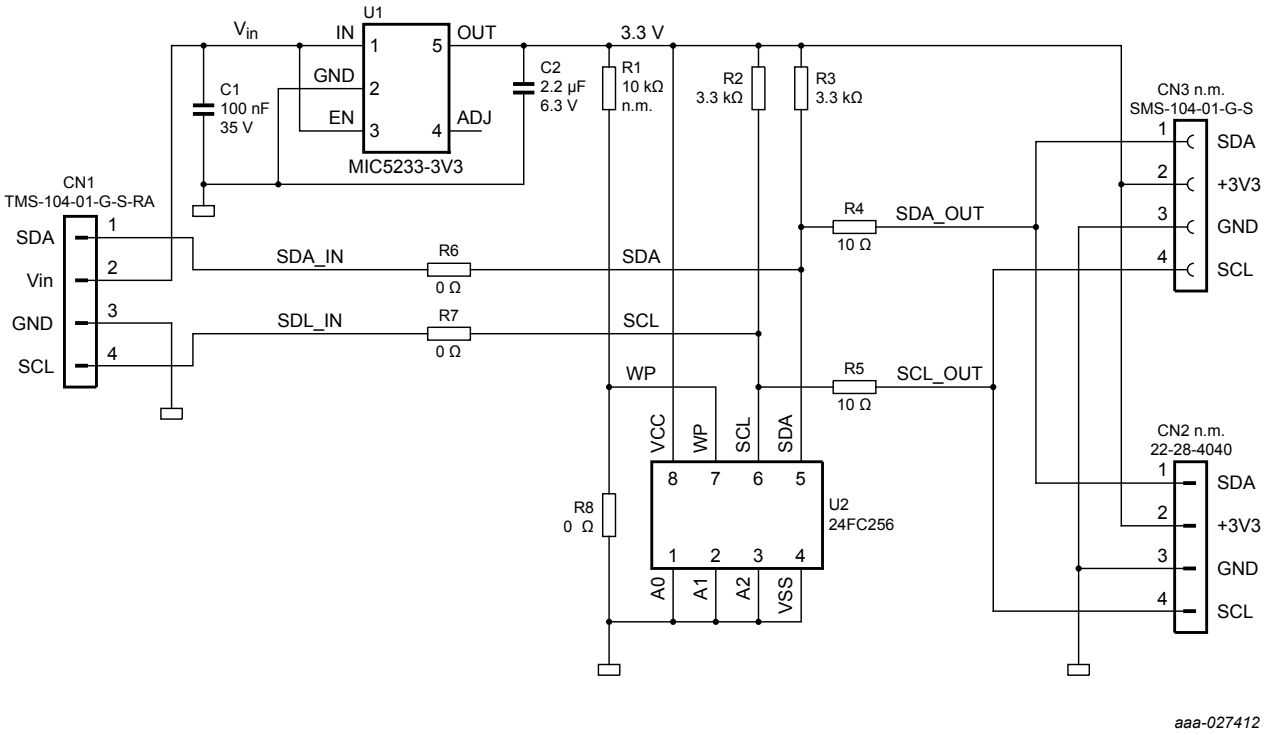


Figure 10. TEA1936xDB1521 schematic diagram



n.m. = not mounted

Figure 11. Optional EEPROM demo board EEPROM_DB1418 with I^2C connections

9 Bill Of Materials (BOM)

Table 8. TEA1936xDB1521 bill of materials

Reference	Description and values	Part Number	Manufacturer
C1	capacitor; 22 µF; 20 %; 400 V; ALU; D13xL17mm	EKM226M2GJ17RR	SAMXON
C3	capacitor; 10 µF; 20 %; 100 V; ALU; THT	100YXJ10M5X11	Rubycon
C4	capacitor; 560 µF; 20 %; 25 V; ALU; THT	A750MS567M1EAAE015	KEMET
C5	capacitor; 100 nF; 10 %; 50 V; X7R; 0402	C1005X7R1H104K050BB	TDK
C6	capacitor; 4.7 µF; 10 %; 25 V; X5R; 0603	C1608X5R1E475K080AC	TDK
C7	capacitor; 4.7 µF; 10 %; 16 V; X5R; 0603	C1608X5R1C475K080AC	TDK
C10	capacitor; 1 µF; 10 %; 25 V; X7R; 0603	-	-
C12	capacitor; 2200 pF; 10 %; 630 V; X7R; 1206	C1206C222KBRAC	KEMET
C14	capacitor; 1 nF; 10 %; 50 V; X7R; 0603	-	-
C15	capacitor; 470 nF; 10 %; 50 V; X7R; 0603	C1608X7R1H474K	TDK
C17	capacitor; 1 nF; 10 %; 50 V; X7R; 0603	-	-
C19	capacitor; 22 pF; 5 %; 50 V; C0G; 0603	-	-
C20	capacitor; 470 pF; 10 %; 100 V; X7R; 0603	-	-
C29	capacitor; 22 µF; 20 %; 400 V; ALU; D13xL17mm	EKM226M2GJ17RR	SAMXON
C30	capacitor; 560 µF; 20 %; 25 V; ALU; THT	A750MS567M1EAAE015	KEMET
C33	capacitor; 22 µF; 20 %; 400 V; ALU; D13xL17mm	EKM226M2GJ17RR	SAMXON
C36	capacitor; 10 µF; 20 %; 35 V; ALU; THT	UVR1V100MDD6TP	Nichicon
C38	capacitor; 10 nF; 10 %; 50 V; X7R; 0402	-	-
C41	capacitor; 4.7 µF; 10 %; 25 V; X5R; 0603	C1608X5R1E475K080AC	TDK
CN1	Connector; USB 3.1 Type-C receptacle R/A	12401548E4#2A	Amphenol
CY1	capacitor; 100 pF; 10 %; 250 V (AC); B; THT; X1/Y2	DE2B3KY101KA2BM01F	Murata
D1	diode; TVS; unidirectional; 24 V; 400 W	PTVS24VS1UR	NXP Semiconductors
D2	diode; ESD protection; 24 V; 3 A	PESD24VS2UT	NXP Semiconductors
D3	diode; 1 kV; 2 A	S2M	Fairchild
D4	diode; 1 kV; 1 A	S1ML	Taiwan Semiconductor
D5	diode; 100 V; 250 mA	BAS316	NXP Semiconductors
D15	diode; 200 V; 250 mA	BAS321	NXP Semiconductors
D17; D25	diode; ESD protection; 30 kV; 3 A	PESD5V2S2UT	NXP Semiconductors
D21; D22; D23; D24	diode; 1 kV; 3 A	AS3PM-M3/86A	Vishay
F1	fuse; slow blow; 250 V; 2 A	MCPMP2A250V	Multicomp
FB2	ferrite bead; 0.009 Ω; 6 A; 0805	BLM21PG220SH1D	Murata
FB3	ferrite bead; K5B RH 3.5 × 4.5 × 0.8	K5B RH 3.5 x 4.5 x 0.8 - T52	King Core Electronics Inc.
L1	inductor CM; EE7.0; Cu = 0.27 mm; 18T:18T	-	NXP Semiconductors

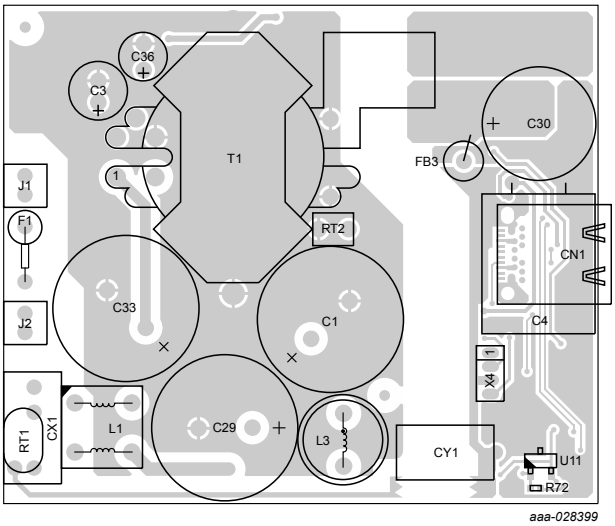
Reference	Description and values	Part Number	Manufacturer
L3	inductor; 120 µH; 850 mA; 0.22 Ω	744772121	Würth Elektronik
Q1	MOSFET-N; 800 V; 0.28 Ω; 17 A	IPD80R280P7ATMA1	Infineon
Q2	MOSFET-N; 100 V; 90 A; 0.006 Ω; TDSON	BSC060N10NS3GATMA1	Infineon
Q3	MOSFET-N; 30 V; 2.4 mΩ; 70 A	PSMN2R4-30MLD	NXP Semiconductors
R5	resistor; 10 Ω; 1 %; 63 mW; 0603	-	-
R7	resistor; 100 kΩ; 1 %; 660 mW; 1206	ERJP08F1003V	Panasonic
R8	resistor; 5.1 kΩ; 1 %; 63 mW; 0402	-	-
R9	resistor; 1 kΩ; 1 %; 63 mW; 0402	-	-
R11	resistor; 330 Ω; 1 %; 63 mW; 0402	-	-
R13	resistor; jumper; 0 Ω; 250 mW; 1206	-	-
R14	resistor; 10 Ω; 1 %; 100 mW; 0402	ERJ2RKF10R0X	Panasonic
R15	resistor; 2.2 kΩ; 1 %; 63 mW; 0603	-	-
R16	resistor; 100 Ω; 1 %; 100 mW; 0603	-	-
R17	resistor; 4.7 Ω; 1 %; 100 mW; 0603	-	-
R18; R19	resistor; 0.43 Ω; 1 %; 250 mW; 0805	ERJS6QFR43V	Panasonic
R21	resistor; 1 kΩ; 1 %; 63 mW; 0603	-	-
R22	resistor; 5.6 kΩ; 1 %; 63 mW; 0603	-	-
R24	resistor; 84.5 kΩ; 1 %; 660 mW; 500 V; 1206	ERJP08F8452V	Panasonic
R25	resistor; 120 kΩ; 1 %; 250 mW; 250 V; 0603	ERJPA3F1203V	Panasonic
R26	resistor; NTC; 47 kΩ; 5 %; 180 mW; 3980 K	B57321V2473J060	EPCOS
R31	resistor; 0.011 Ω; 1 %; 1 W; 1206	ERJ8CWFR011V	Panasonic
R39	resistor; 1 MΩ; 1 %; 63 mW; 0402	CRCW04021M00FKED	Vishay
R50	resistor; 120 Ω; 1 %; 100 mW; 0402	ERJ2RKF1200X	Panasonic
R53	resistor; 178 kΩ; 1 %; 63 mW; 0402	-	-
R54	resistor; 24.3 kΩ; 1 %; 63 mW; 0402	-	-
R55	resistor; 150 Ω; 1 %; 100 mW; 0402	ERJ2RKF1500X	Panasonic
R60	resistor; 3.3 kΩ; 1 %; 63 mW; 0402	-	-
R61	resistor; 10 Ω; 1 %; 100 mW; 0402	ERJ2RKF10R0X	Panasonic
R62	resistor; 47 Ω; 1 %; 500 mW; 0805	ERJP6WF47R0V	Panasonic
R64	resistor; 84.5 kΩ; 1 %; 660 mW; 500 V; 1206	ERJP08F8452V	Panasonic
R69; R70	resistor; 10 Ω; 1 %; 100 mW; 0402	ERJ2RKF10R0X	Panasonic
R71	resistor; jumper; 0 Ω; 100 mW; 0402	ERJ2GE0R00X	Panasonic
RT2	resistor; NTC; 100 kΩ; 5 %; 100 mW; 4190 K	NTCLE100E3104JB0	Vishay

Reference	Description and values	Part Number	Manufacturer
T1	Transformer; RM8; 360 µH	RM8	NXP Semiconductors
U1	USB-PD Type-C controller	TEA19031T (SO10)	NXP Semiconductors
U2	synchronous rectification controller	TEA1993	NXP Semiconductors
U10	SMTP controller; TEA19361	TEA19361	NXP Semiconductors
U3	optocoupler; NPN; 70 V; 50 mA	TCLT1008	Vishay

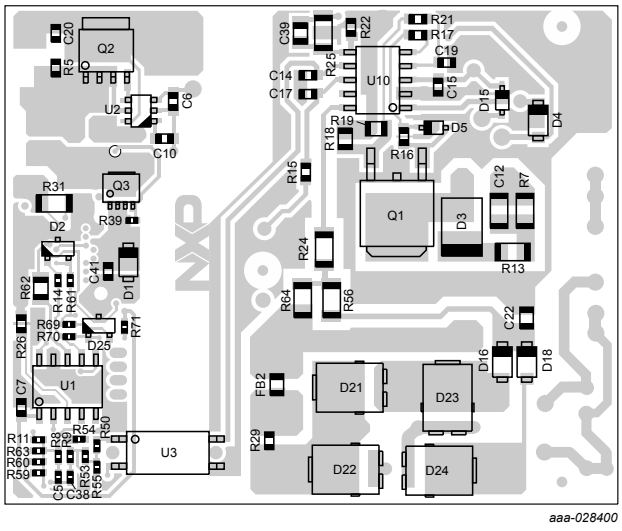
Table 9. EEPROM_DB1418 bill of materials

Reference	Description and values	Part Number	Manufacturer
C1	capacitor; 100 nF; 10 %; 35 V; X7R; 0402	-	-
C2	capacitor; 2.2 µF; 20 %; 6.3 V; X5R; 0402	GRM155R60J225ME15D	Murata
CN1	header; right angle; 1 × 4-way; 1.27 mm	TMS-104-01-G-S-RA	SAMTEC
CN2	header; not mounted; straight; 1 × 4-way; 2.54 mm	22-28-4040	Molex
CN3	receptacle; not mounted; straight; 1 × 4-way; 1.27 mm	SMS-104-01-G-S	SAMTEC
R1	resistor; not mounted; 10 kΩ; 1 %; 63 mW; 0402	CRCW040210K0FKED	Vishay
R2	resistor; 3.3 kΩ; 1 %; 63 mW; 0402	CRCW04023K30FKED	Vishay
R3	resistor; 3.3 kΩ; 1 %; 63 mW; 0402	CRCW04023K30FKED	Vishay
R4	resistor; 10 Ω; 1 %; 200 mW; 0402	ERJ-PA2F10R0X	Panasonic
R5	resistor; 10 Ω; 1 %; 200 mW; 0402	ERJ-PA2F10R0X	Panasonic
R6; R7; R8	resistor; jumper; 0 Ω; 63 mW; 0402	CRCW04020000Z0ED	Vishay
U1	LDO; 3.3 V	MIC5233-3.3YM5 TR	MICREL
U2	EEPROM; 256 kb; I^2C; CMOS	24FC256-I/SN	Microchip

10 Layout

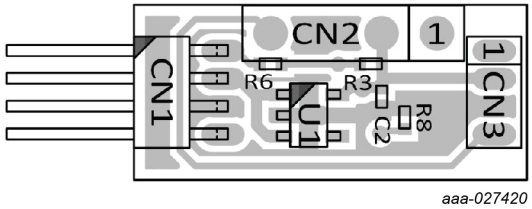


a. Top view layout and assembly

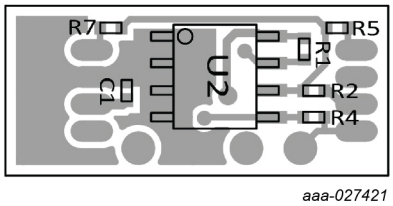


b. Bottom view layout and assembly

Figure 12. TEA1936xDB1521 demo board layout



a. Top view and assembly



b. Bottom view and assembly

Figure 13. EEPROM_DB1418 demo board layout

11 Abbreviations

Table 10. Abbreviations

Acronym	Description
USB	Universal Serial Bus
PD	Power Delivery
QC	Quick Charge
UTC	Universal Type-C Controller
PDO	Power Data Object
MTP	Multiple Times Programmable
TEO	TEA190x Evaluation Overdrive

12 References

[1] **UM11014 user manual** — TEA190x Evaluation Overdrive (TEO); 2017, NXP Semiconductors

13 Legal information

13.1 Definitions

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